

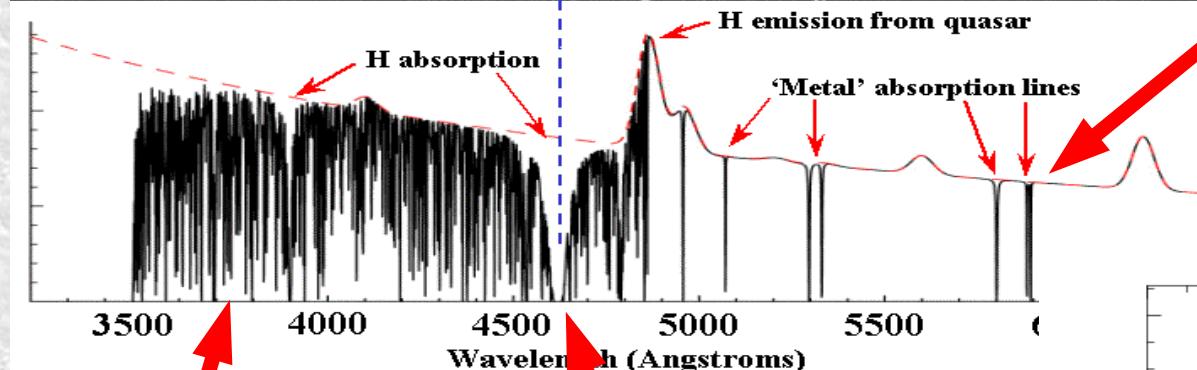
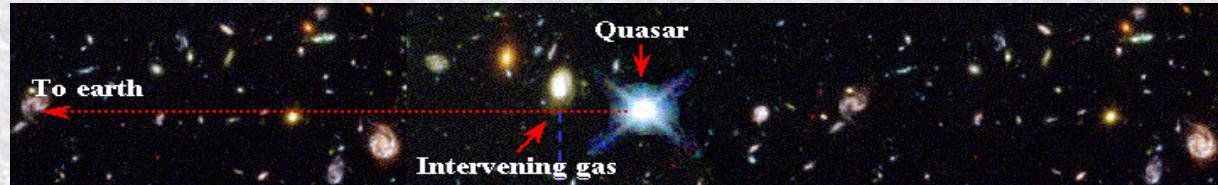
# X-ray absorption from the Damped Lyman Alpha Systems

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Jill Bechtold (Steward Observatory)

# Outline

- What are DLA systems?
- Why X-rays?
- Chandra observations of low/high redshift systems.
- Chandra and XMM-Newton observations of B2 0738+393
- Future with Con-X.

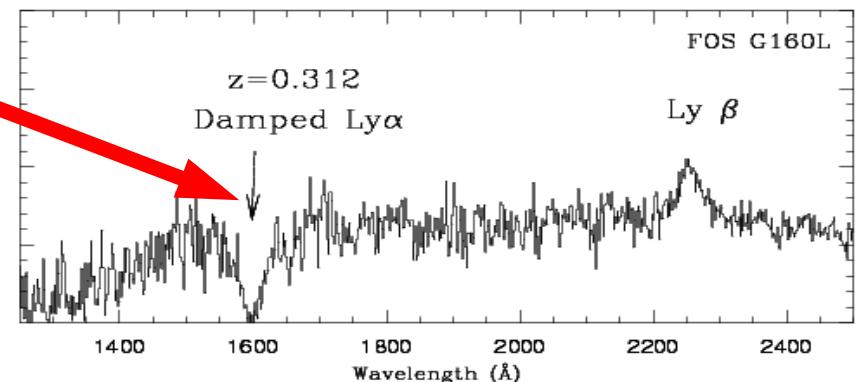
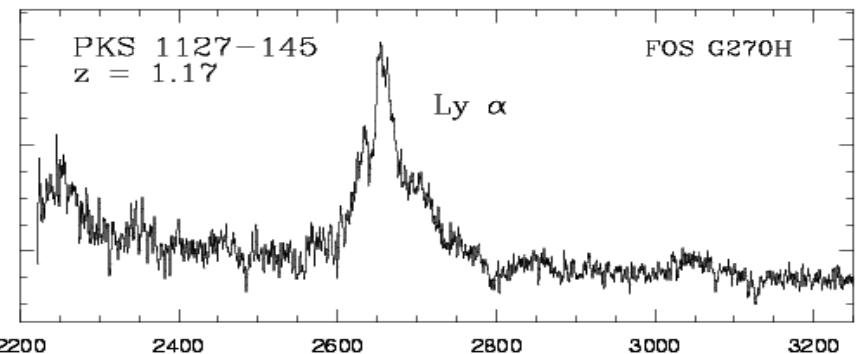
# Quasar Absorption



Ly $\alpha$  forest

Damped Ly $\alpha$

'Metal' lines



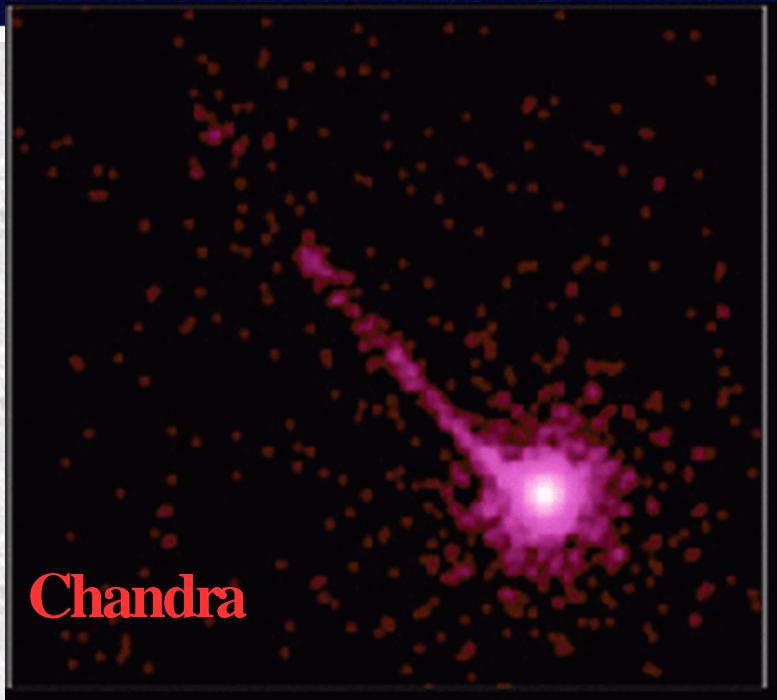
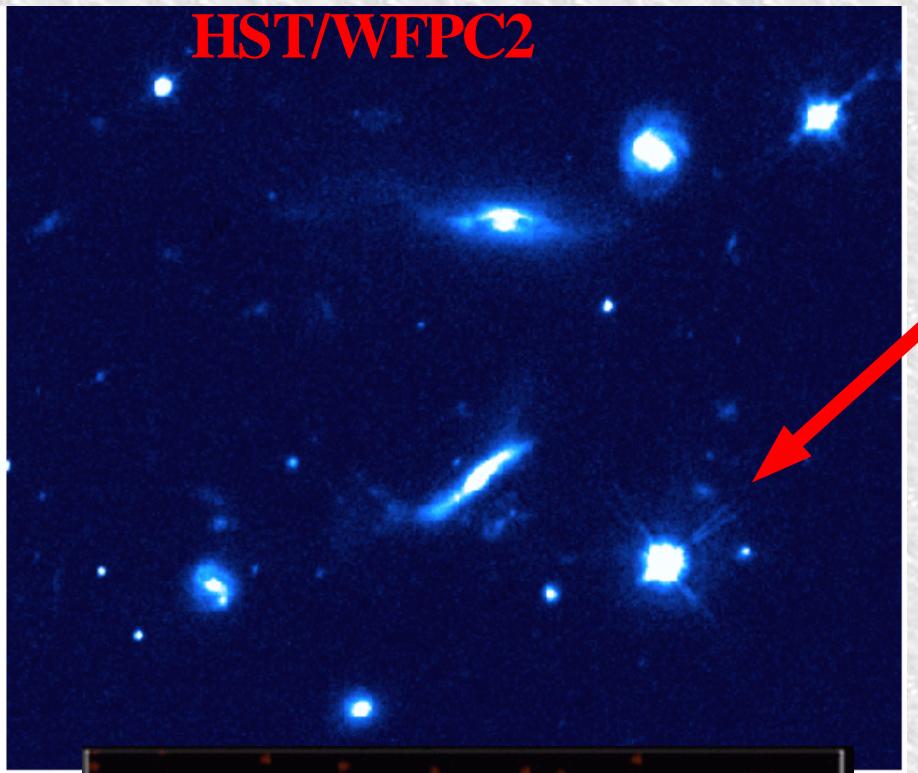
Webb, www  
page  
also Pettini 2003

HST/FOS, Bechtold et al (2001)

# Damped Ly-alpha absorption

- Absorption systems on the line of sight towards quasars with  $\mathbf{N(HI) > 2 \times 10^{20} \text{ cm}^{-2}}$
- The **highest N(HI)** among QSO absorption systems.
- Some systems can be identified with galaxies.
- Metallicity at different redshift => structure formation.
- Why X-rays? Optical/UV limitations

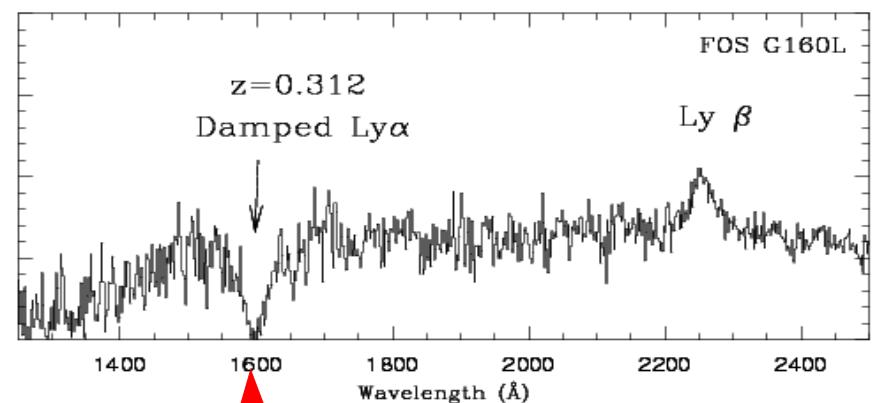
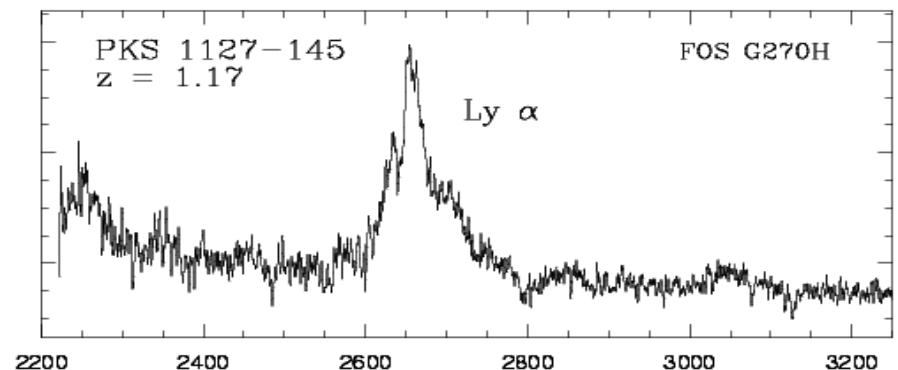
HST/WFPC2



Chandra

# Quasar Absorption

PKS1127-145

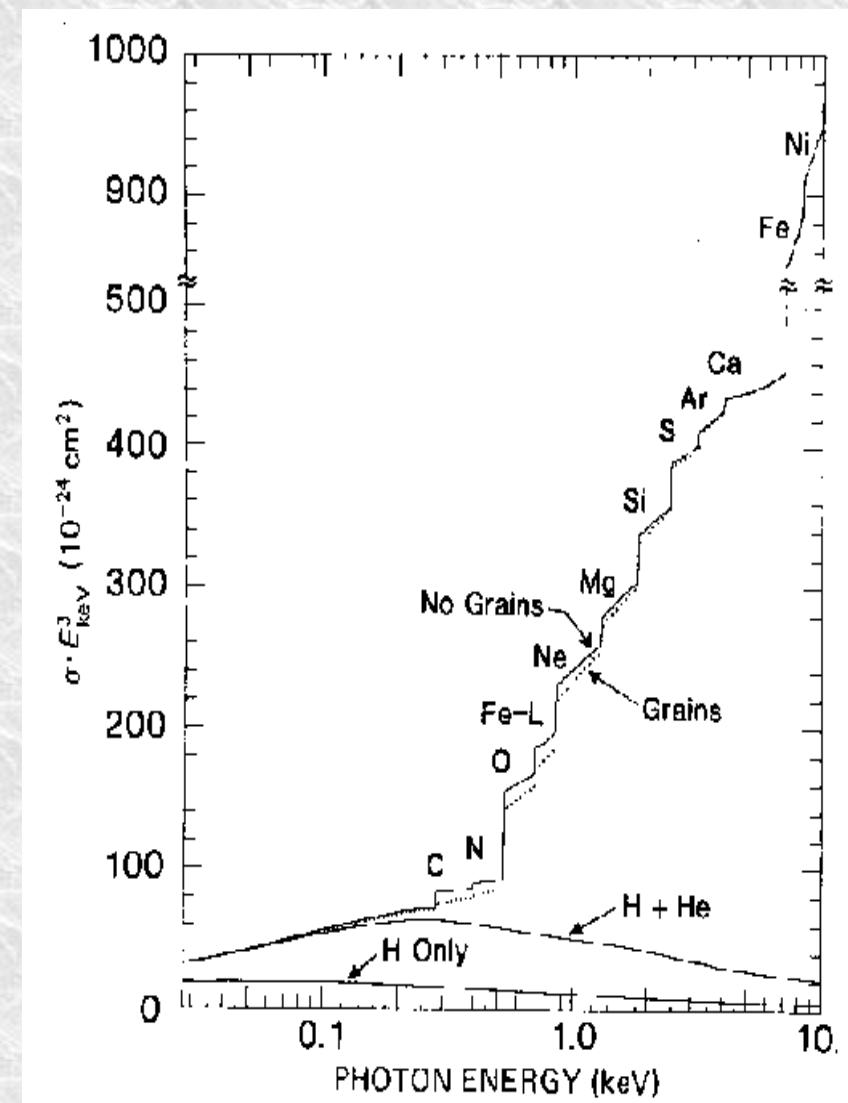


DLA

Bechtold *et al* 2001, Siemiginowska *et al* 2002

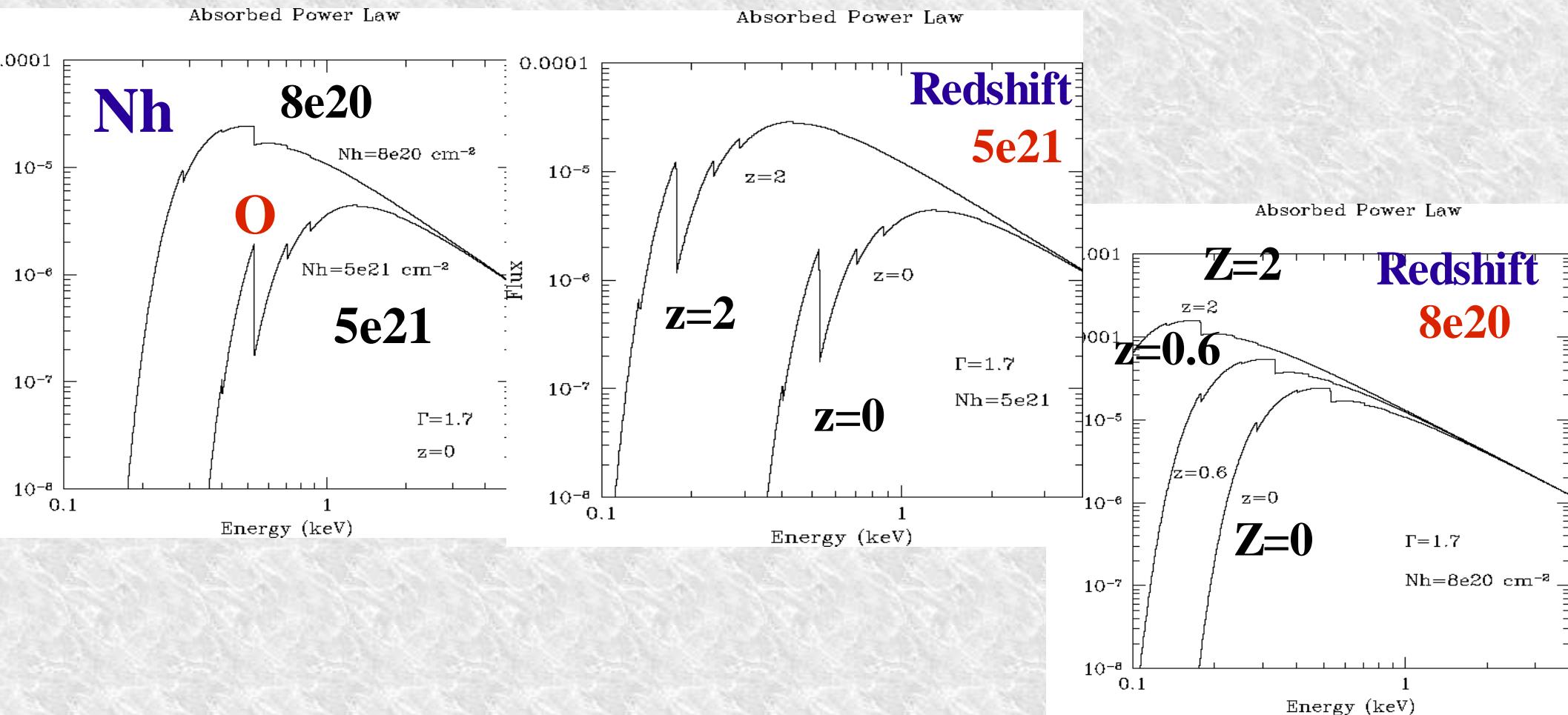
# X-ray Absorption

- Soft X-ray absorption primarily due to => **Helium, Carbon and Oxygen**
- Dust independent .
- UV lines are saturated.
- H Ly $\alpha$  measurements give N (HI) column.
- Compare X-ray absorption to Zinc (undepleted) => relative abundance of Fe group to alpha group
- Pop II has enhanced O/Fe



M&MC 1983

# Photoelectric Absorption in X-rays



# Chandra Observations

- Five systems:
- Different redshifts
- High redshift vs. low redshift

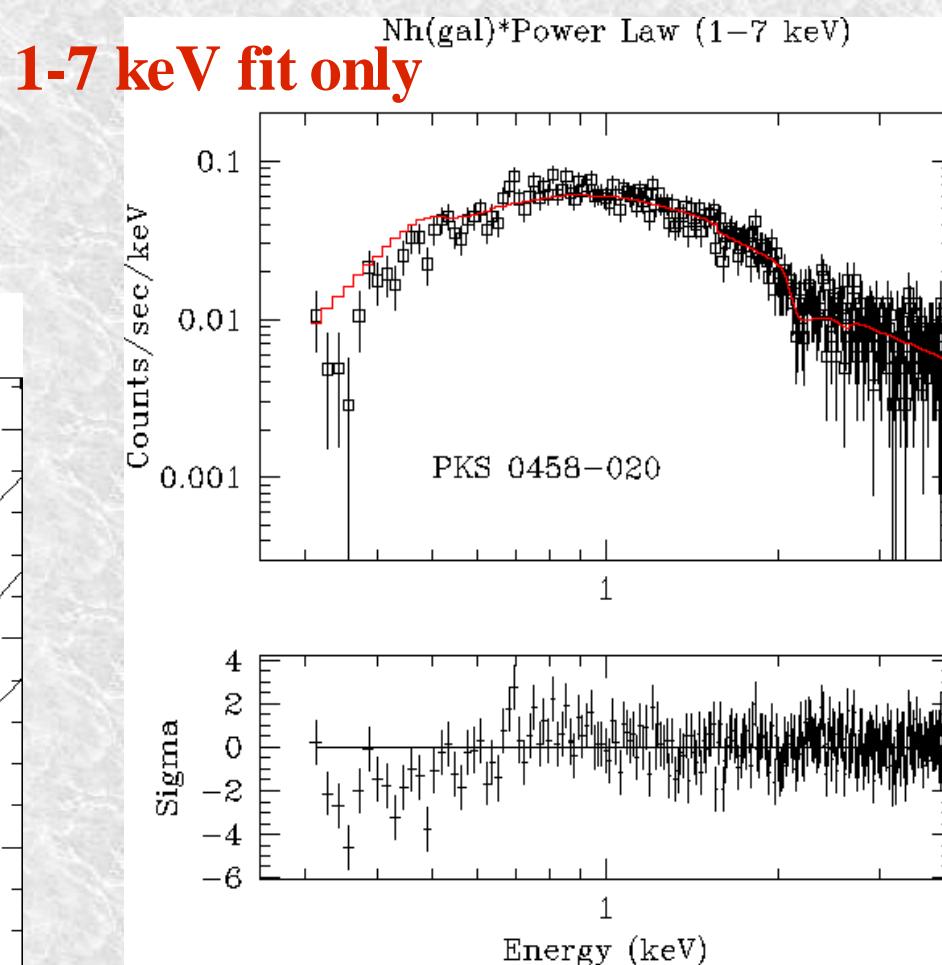
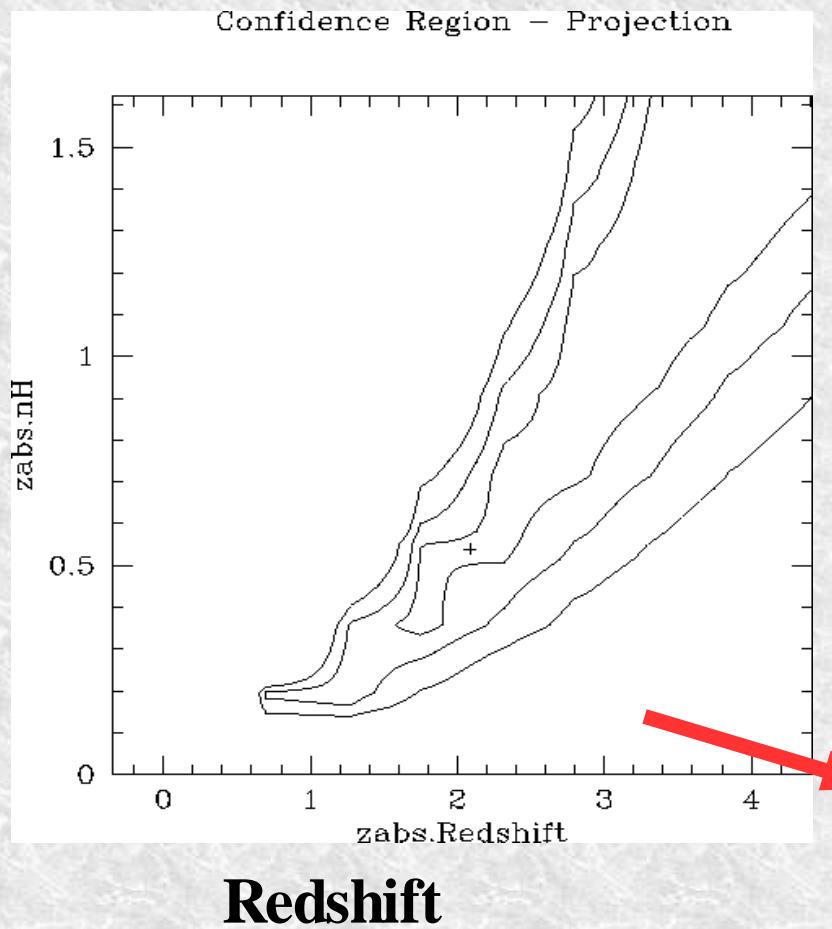
QSO	$z_{\text{qso}}$	$z_{\text{abs}}$	$N(\text{gal})^*$	$N(\text{HI})^*$	Chandra Ref
B2 0738+393	0.63	0.091	0.48	1.5	<i>Siemiginowska et al</i>
		0.221		0.8	
PKS 1127 -145	1.19	0.312	0.33	$5.1^{+/-0.9}$	<i>Bechtold et al</i>
S4 0248+430	1.31	0.394	0.89	$3.9^{+/-0.6}$	<i>Turnshek et al</i>
AO 0235+164	0.94	0.524	0.39	$4.5^{+/-0.4}$	<i>Turnshek et al</i>
PKS 0458-02	2.29	2.04	0.76	8.0	<i>Bechtold et al</i>

\*  $1\text{e}21 \text{ cm}^{-2}$

# PKS 0458-020 High Redshift DLA

- $Z_{\text{qso}} = 2.2$   $z_{\text{abs}} = 2.04$

$N_H(10^{22})$



$$\Gamma = 1.77^{+/-0.05} \quad N_H(\text{gal}) = 7.5 \times 10^{20} \text{ cm}^{-2}$$

$$N_H(z_{\text{abs}}=2.04) = 5.3^{+/-0.9} \times 10^{21} \text{ cm}^{-2}$$

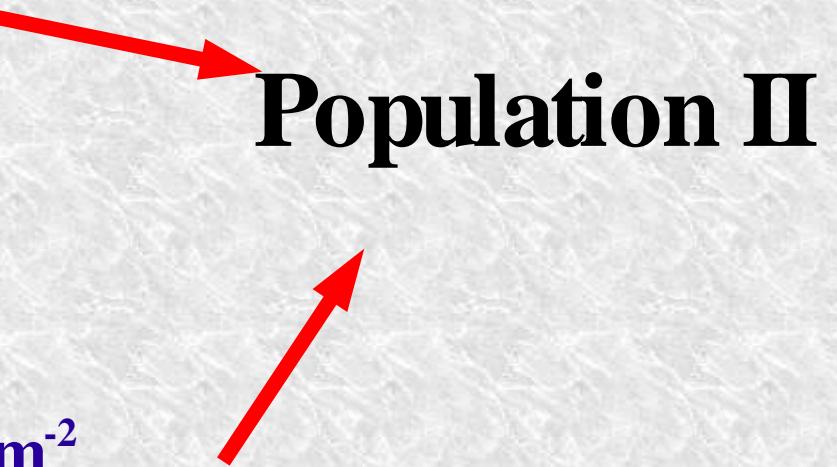
# PKS 0458-020 High Redshift DLA

- $Z_{\text{qso}} = 2.29$   $z_{\text{abs}} = 2.04$
- $\text{Zn}\Pi \Rightarrow \text{Zn/H} = 0.059 \pm 0.022$

$$\Gamma = 1.77^{+/-0.05}$$

$$N_{\text{H}}(\text{gal}) = 7.5 \times 10^{20} \text{ cm}^{-2}$$

from  $H(\text{Ly } \alpha) \Rightarrow N(\text{HI}) = 8 \times 10^{21} \text{ cm}^{-2}$   
 $\Rightarrow \text{O/H} = 0.39 \pm 0.32 (3\sigma)$

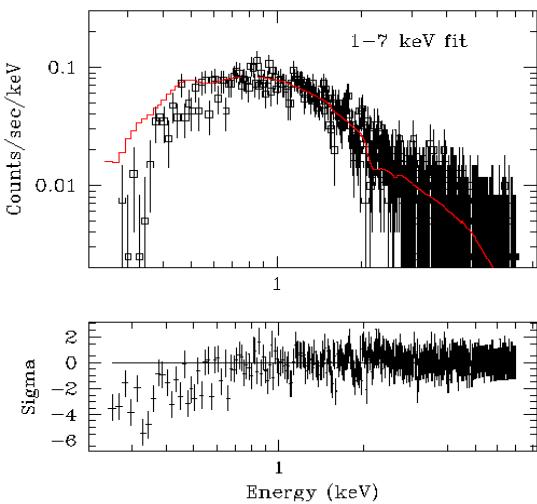


# B2 0738+393

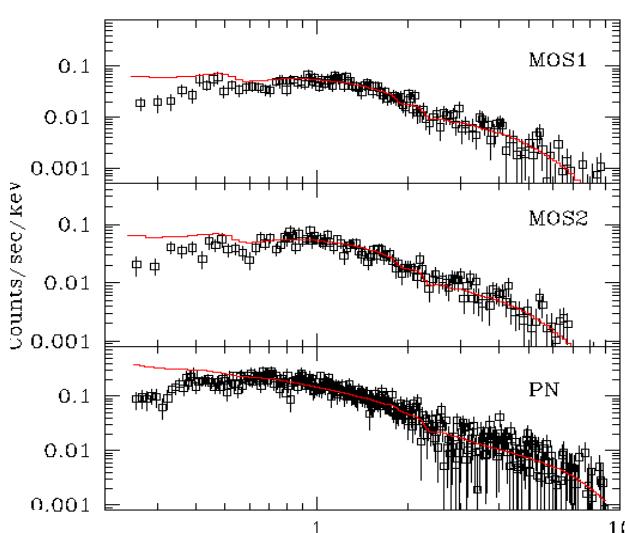
- Low redshift radio-loud Quasar at z=0.63
- $L_{bol} \sim 10^{46}$  ergs $\sim$ sec $^{-1}$
- **Two DLA** systems at: z=0.0912 and z=0.2212;
- Chandra ACIS-S => 27 ksec exposure.
- XMM-Newton => 20 ksec exposure

# B2 0738+393 Chandra/XMM

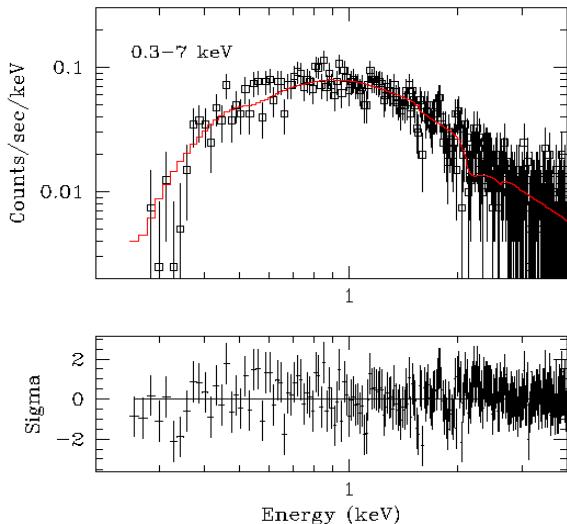
**1-7keV** B2 0738+393 Chandra



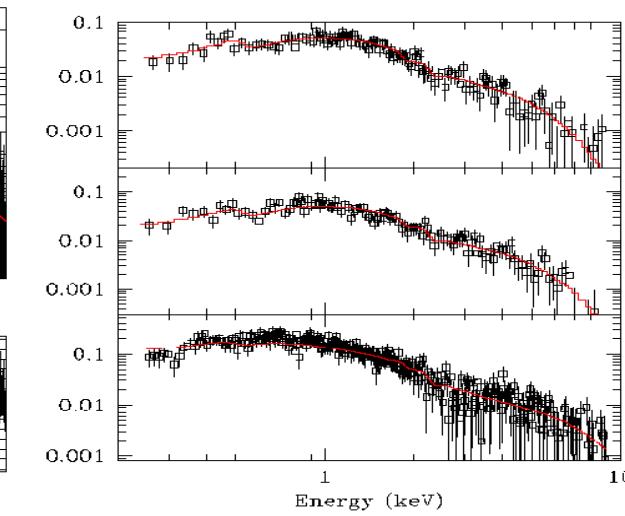
**1-9keV** B2 0738+393 XMM-Newton



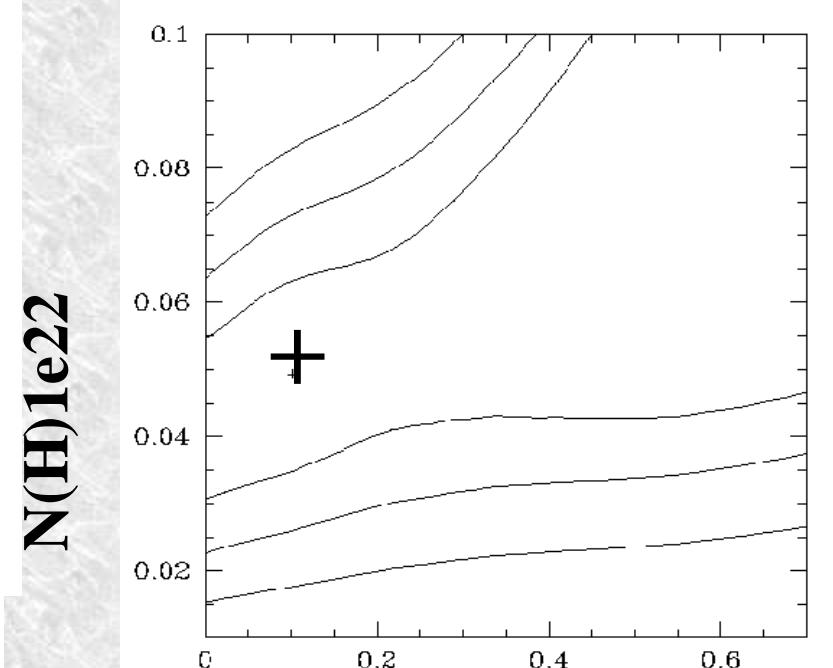
**0.3-7keV** B2 0738+393 Chandra



**0.3-9keV** B2 0738+393 XMM-Newton



N(H)1e22



Redshift

$$N(z_{\text{abs}}=0.09) = 5.1^{+0.7}_{-0.7} \text{ e}20 \text{ cm}^{-2}$$

$$N(z_{\text{abs}}=0.22) = 6.3^{+0.7}_{-0.7} \text{ e}20 \text{ cm}^{-2}$$

$$N(z_{\text{qso}}=0.63) = 1.1^{+0.1}_{-0.1} \text{ e}21 \text{ cm}^{-2}$$

Chandra

XMM

# **Can we trust the results? Data Analysis Issues**

- **Chandra analysis**
  - ACIS Contamination =>
    - time-dependent QE variations
  - No good calibration below ~0.8 keV
- **XMM analysis**
  - High background =>
    - higher total number of counts, but background at soft energies causes difficulties.

# Future: Constellation-X

Simulations: `calor_w_grat.rsp`

**Model :**  
**based on B20738+393 data**

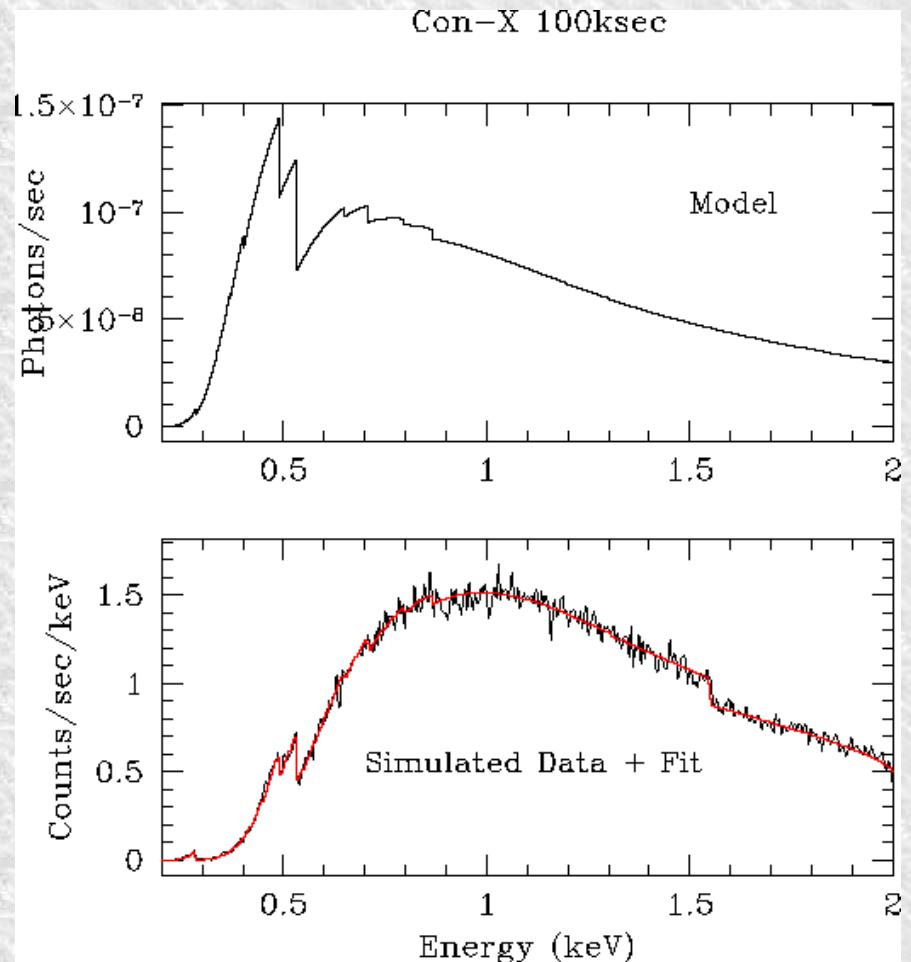
$$N(H_{\text{gal}}) = 4.78 \times 10^{20} \text{ cm}^{-2}$$

$$N(H_{\text{abs1}}) = 6 \times 10^{20} \text{ cm}^{-2} @ z=0.09$$

$$N(H_{\text{qso}}) = 6 \times 10^{20} \text{ cm}^{-2} @ z=0.63$$

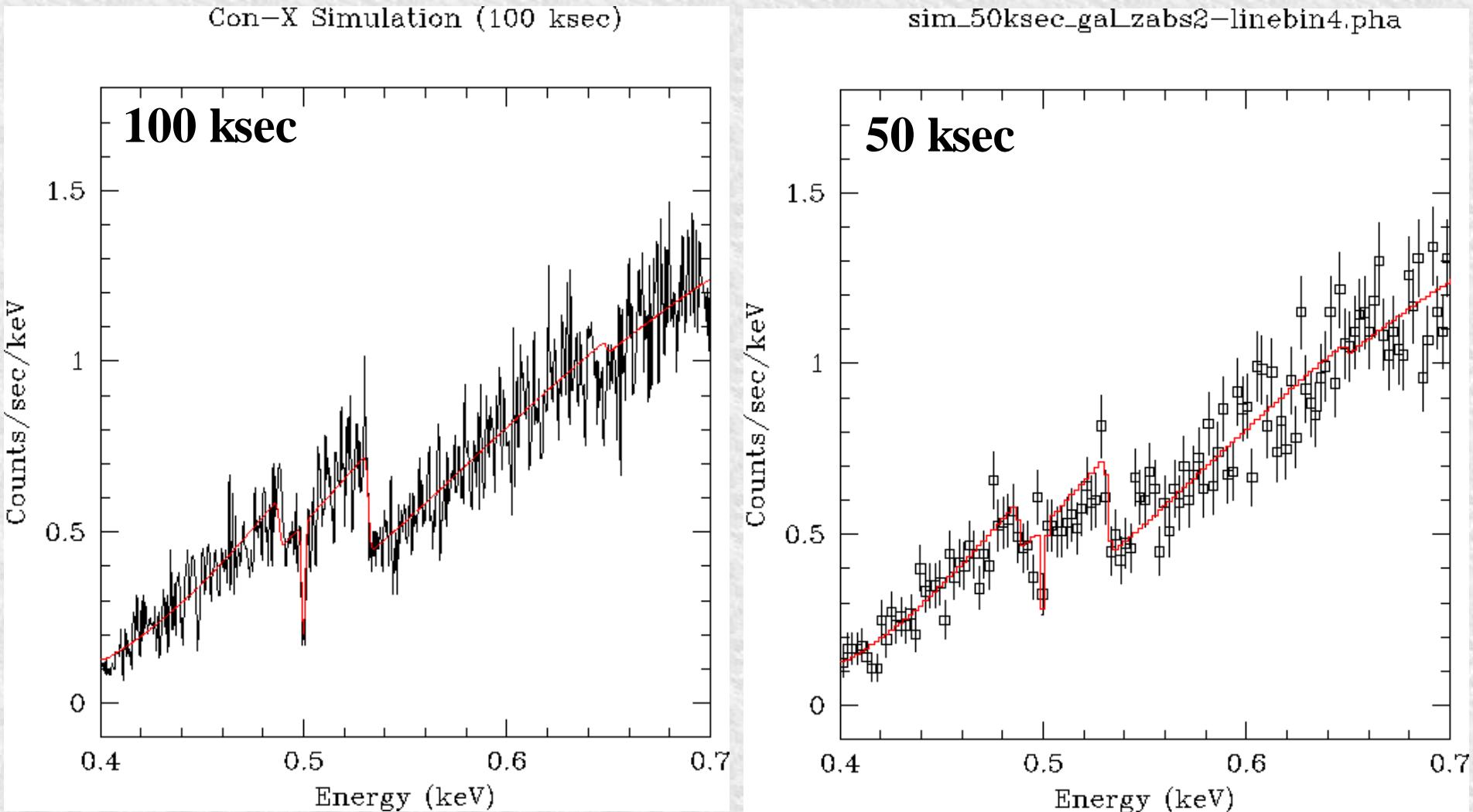
$$\Gamma = 1.9$$

$$F(0.2-5\text{keV}) = 7.5 \times 10^{-13} \text{ ergs cm}^{-2} \text{ s}^{-1}$$



# Simulations: Absorption Lines

- => Lines observed in Milky Way: (*Schultz talk, Pearels 2001*)
- => the strongest O-K $\alpha$
- => assumed  $E_{\text{line}} = 0.5 \text{ keV}$     EW = 1.2 eV



# What is the background contribution?

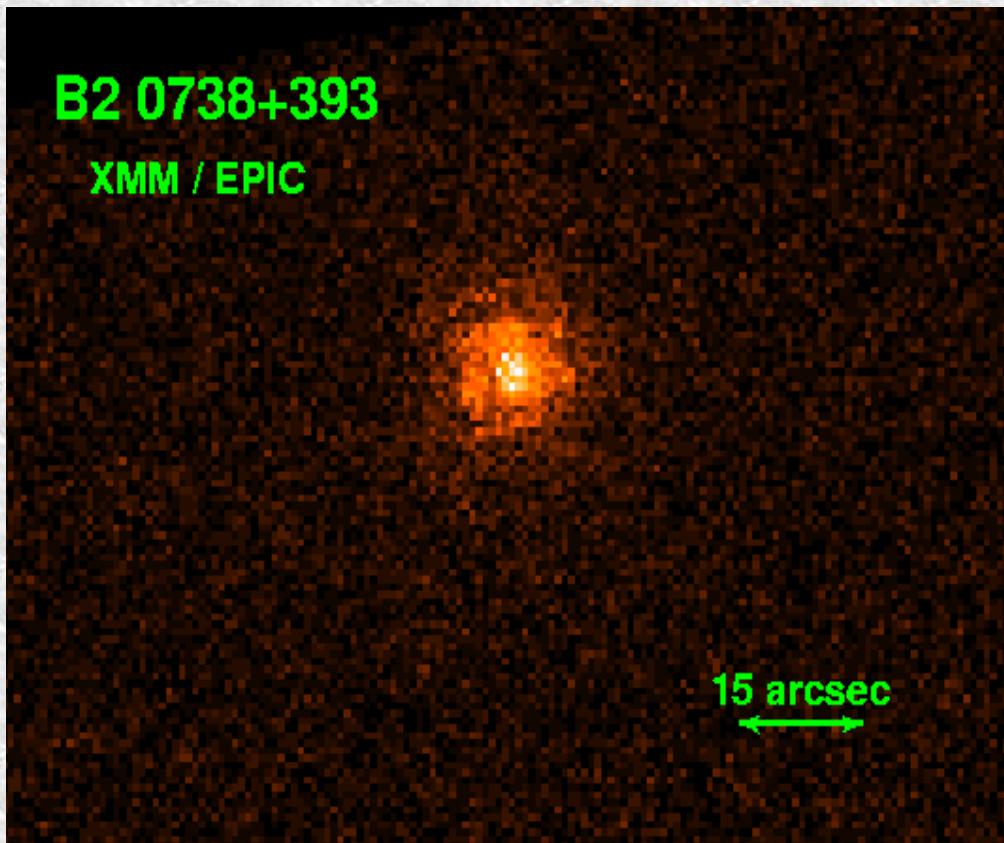
Based on ACIS-S observation of B20738 +393  
Flux (0.2-5 keV) = $7.5 \times 10^{-13}$  erg/cm<sup>2</sup>/s

Using PIMMS:

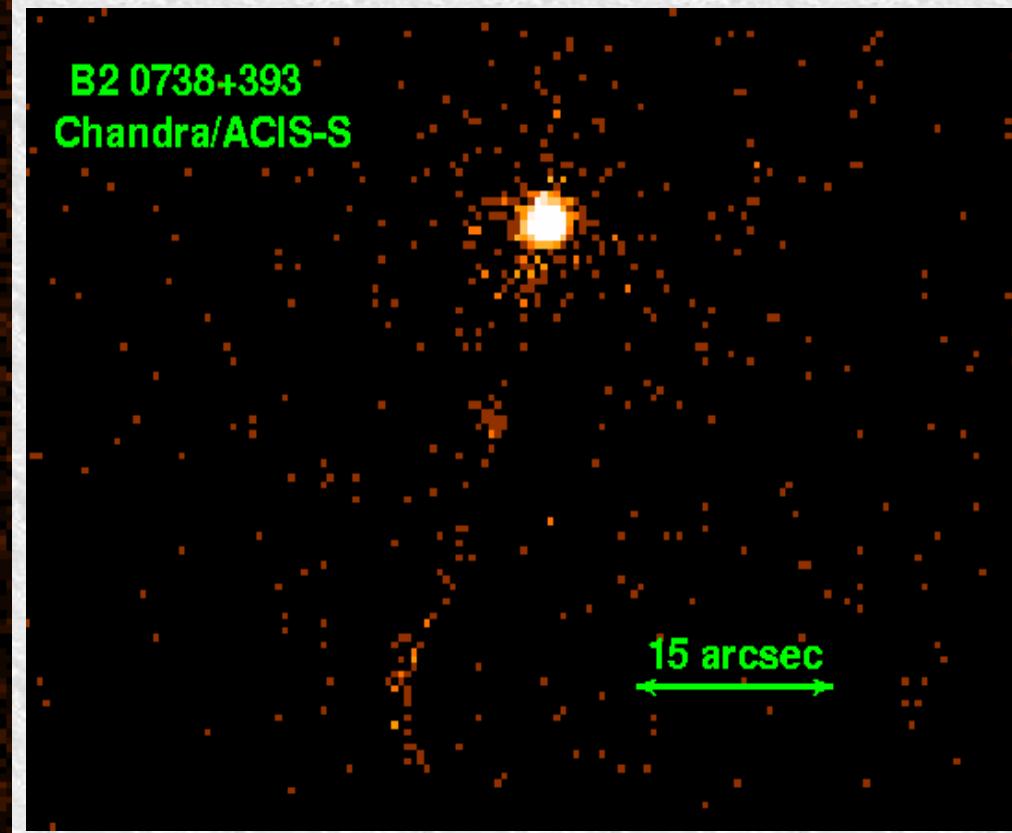
	Cal	Gratings	Flux (Bkg=Src)	
	cts/s	cts/s	[ $10^{-12}$ erg/cm <sup>2</sup> /s]	
10"	0.8	0.16	0.17	0.11
15"	1.8	0.36	0.38	0.24
30"	7.2	1.44	<b>1.5</b>	<b>1.06</b>

# Conclusions

- Chandra and XMM detection of absorption in PKS 0458-020 and B2 0738+393.
- No redshift information
- Need high resolution, high S/N observation to determine the absorber's redshifts
- Detection of absorption edges and lines with Con-X can provide the unambiguous redshift measurements.



$\sim 20$  ksec



$\sim 27$  ksec